

A STUDY OF THE COCONUT FLOWER AND ITS RELATION TO FRUIT PRODUCTION.

Introduction.

The literature on the biology of pollination and fruit production of coconuts is extremely sparse and what little is available is distributed in numerous books and periodicals so that investigators have experienced great difficulties in consulting them. An attempt is made here to bring together all the available studies on the subject, including my own observations, a part of which have already been published in the *Poona Agricultural College Magazine* and the *Agricultural Journal of India* ⁽¹⁰⁾.

I am indebted to Mr. I. H. Burkill for the information quoted in this paper from the German and Dutch books and to Mr. F. N. Chasen for the identification of some of the insect visitors to coconut flowers.

The Inflorescence.

Coconut inflorescences are formed in the axils of every leaf of a bearing tree and not of every third leaf as some writers have supposed ⁽⁸⁾ & ⁽¹⁷⁾. It is true that some axils fail to throw out any inflorescences, but this is because these inflorescences have become abortive; and even then these aborted inflorescences do not bear any definite relation to the others which grow so as to justify the statement that the inflorescences are produced in the axil of every third leaf. A very prolific tree will produce twelve or more inflorescences per annum or approximately one per month. There are records of trees having produced sixteen inflorescences per year ⁽²⁾ & ⁽¹⁷⁾.

As the flowers appear in the axils of leaves, it will be worth while to know that the leaves are arranged on the stem in the form of a spiral so that every sixth leaf opens, nearly above the first one, that is, each leaf opens according to the calculation of Sampson in India ⁽²¹⁾, at an angle of approximately 142° round the circumference of the tree from the previous leaf. In Goa the coconut harvester divides the coconut trees under two classes, the right- and left-handed ones, according as the spirals formed by the leaves and, therefore, by the inflorescences, are right or left. Both Costa ⁽⁸⁾ and Loyola ⁽¹⁷⁾ who maintain that the coconut inflorescences arise in the axils of every third leaf give correct diagrams of the phyllotaxis of the coconut inflorescences. They were probably misled in their observations on the orientation of the coconut inflorescence by their mistaken view that the coconut leaves are arranged in concentric circles and not in a spiral.

The inflorescences first appears enclosed in a thick, fibrous sheath called the spathe which is again protected during its early life by one more yellow sheath of somewhat flat nature and of softer fibres. This outer sheath stops growing very early in the life of the inner spathe so that the latter punctures it with its hard point on

its ventral side (*i.e.* the side towards the subtending leaf) and comes out erect as a yellow somewhat flattened cone, which later on as it grows, turns green, curves a little outwards and becomes more round than flat. In course of time when the spathe is of full grown, the development and distension of the inflorescence within causes a great pressure on the walls of the spathe with the result that it ruptures longitudinally along a groove usually on its ventral side and the flowering branch eventually emerges: sometimes, however, the rupturing of the spathe takes place on its dorsal side but then the spadix turns round till the inflorescence within falls out. The process of splitting is very slow, the slit which appears at first at a point about an inch and half from the apex, takes about twenty-four or more hours to reach down and give egress to the inflorescence. It is at first yellowish white in colour, but later on it turns greenish and also inclines downwards from its vertical position.

The cocount is essentially a monoecious plant, that is, stamens and pistils are produced in separate flowers on the same tree and in the case of coconuts in the same inflorescence, and, though some coconut palms will at times show a very marked tendency to produce spadices with all florets male, spadices are not usually produced in coconuts where all flowers are female and none male. The tendency to produce completely male inflorescences is particularly apparent when the palm produces the spathe for the first time in its life. There is a great variation in such trees: some will produce their second or third inflorescence with female flowers, while others will bear no female flowers even in the sixth inflorescence. If this variation is due to hereditary qualities, then this factor has also to be taken into consideration in selecting seed-nuts. The tendency to produce completely male inflorescences is at times manifested by trees which are given rest after a prolonged period of tapping for toddy.

The inflorescence itself consists of many flower-bearing ramifications or spikelets situated on a fleshy peduncle: hence the inflorescence is termed a spadix. Its size varies from two and half to six feet in length from the tip to the base, depending upon the vigour and individuality of the palm. Each branch is fringed with numerous male florets from tip downwards and lower down bears one or more female flowers, all the flowers being sessile or subsessile as Aldaba calls it. At times, however, some of these ramifications become spatulate and then partially or wholly sterile. Some of the branches in an inflorescence may produce secondary branches. As far as my observations stands, such inflorescences rarely produce female flowers which may be produced even on the secondary branches. Most of these inflorescences were noticed on trees heavily manured with nitrogenous manures, but I was not able to ascertain whether the manure was responsible for the branching and reduced fertility of these spadices.

The Male Flower.

The male flowers always exceed the number of female flowers in the same spadix and may vary from a few hundreds to thousands, depending upon the number of ramifications in the spadix and the length of the flower-bearing regions in them. Each male floret has six yellow perianth leaves arranged in two whorls, the inner three alternating with others which are about one-third of the former in size. Enclosed in this floral envelope there are six hammer-shaped stamens which yield large quantities of powdery yellow pollen. Aldaba (¹) has estimated that each male flower carries about 272, 358, 504 pollen grains. In the centre of each male floret there is a rudimentary pistil which divides at its apex into three teeth, each bearing a gland, the nectar of which attracts ants, bees and other creatures. Rarely this rudimentary pistil is absent (¹⁹). A case has been noted where these abortive ovaries were stimulated to grow so that the coconut palm bore, "instead of the few ordinary fruits at the base of the spadix, great numbers of small, crowded, narrow, quite banana-like fruits." (²⁵) The male florets start opening from the tip downwards and liberate pollen, though sometimes a few flowers may open out of order. This opening of male flowers and shedding of the pollen lasts about a month, the inflorescences with secondary branches taking a little more than the usual period.

The Female Flower.

The female flower are comparatively extremely few, their number in each spadix varying from zero to over 300 and being dependent upon the strain, treatment, etc. They are always produced towards the basal portions of the spikelets. Many of the yellow-nut-producing varieties from the Konkan (West Coast of India), for instance, are usually very shy in bearing, while the dwarfish varieties of Goa (the *Benauly* seed) or dwarf varieties of Malaya enjoy the reputation of being heavy producers.

Prior to its opening, the female flower is a small spherical body of about half an inch in diameter with a great resemblance to a small nut. These female flowers consist of six floral leaves which are arranged as in the male flowers and which completely envelope the pistil; but these are much larger and stiffer than those in the male florets, and the outer three are almost equal in size to the inner ones. Apart from these six perianth members, there are two more just at the point of attachment of the flowers to the stalk, resembling the others in colour and texture, but differing from them in that they are broader and shorter. These two may be termed prophylls or bracteoles. Usually there is a male flower on each side of the female resting on the same cushion on which the female is seated. The pistil is a small whitish body consisting principally of embryonic tissue of husk. From its tip there extend downwards three ridges which make the whole ovary look globosely three-sided, each side being provided at its tip with a groove. These three grooves meet in the centre and are the parts of the stigma. It will

be seen by cross-sectioning the pistil that just above the thalamus there is the ovary (embryonic nut) with its three carpels, two of which normally become abortive even at this early stage. Sometimes, however, all three ovules get developed and when fertilised produce a trilocular-nut which on germination gives a tree commonly mistaken for a branched coconut palm.

Pollination and Fertilization.

Before proceeding any further a distinction between Pollination and Fertilization may be made with advantage so as to avoid confusion on this matter. Among the fruit culturists, the term pollination is often applied to designate all the influences concerned in the setting of fruits; and the term fertilization is often given the same significance. In botanical usage, however, pollination means simply transference of pollen grains to the stigma, while fertilization is the fusion of the male element from the pollen with the female element in the ovule, and therefore, conveys the idea that, prior to this fusion, the stigma has to be pollinated and the male element must reach the ovum through the pores in the stigma. Cases, however, may occur where these two stages previous to the fertilization may take place and stimulate the pistil to grow and yet the actual fusion may not eventuate producing seeds destitute of any of embryo. The coconut fruits known as "barren" "imperfect," "male," "man" or "seedless" coconuts are probably a result of such a phenomenon. Such nuts have been observed by me in India and Burma, have been recorded from Jamaica ⁽¹⁶⁾ and British Guinea ⁽³⁾, and probably occur in most places where coconuts are grown. They can usually be distinguished from others by being narrower, and inside have shell-substance and a cavity and sometimes even a diminutive nut with or without some kernel, but no embryo. Apparently the stimulus of pollen is not even necessary for such a development in coconuts, for Bailey ⁽⁴⁾ has written that "Coconuts, like many other fruits, often grow to a considerable size without pollination, and then perish." It must not be ignored, however, that a fruit without an embryo may be the consequence of actual fertilization, but that it does not contain any embryo, because the embryo ceased to grow soon after the fusion of male and female element in the ovule without thereby arresting the development of the fruit. A comparative study of these abnormal coconuts and normal ones from Jamaica made by Kupfer ⁽¹⁶⁾, indicated that the substance which usually goes to the formation of seed was, in the case of seedless nuts, devoted to increasing the bulk of husk. "Since no trace of fungus, insect, or bacterial activity could be found, no direct evidence as to the cause of the condition of the defective fruits could be produced. The probability is, however, that the responsibility for this state of the fruiting organs is to be laid against none of these agents, but is the result of the failure on the part of flower to effect pollination."

Some coconut trees produce "male" nuts habitually in all seasons of the year and others in certain seasons only of every year

or after a number of years; and still others do not produce male nuts at all or produce only this kind of fruit all their life. Might not this quality be associated with hereditary factors? In many plants, for instance, the production of sterile pollen grains and ovules is due to an inherent factor, though influences such as climate may modify these qualities to a slight extent. On the other hand, there is the possibility that the inability of ova being fertilized lies in the fact that the nutrition is defective; for it has been shown by experiments that weak and poorly nourished orchard trees often produce ineffective pollen, or unfavourable weather conditions cause great losses by preventing the proper maturity of the pollen or pistil. Aldaba ⁽¹⁾ has shown that desiccating influences reduce the vitality of pollen, while it is a matter of common belief among planters that heavy downpours of rains excessive cold, heat and winds, or prolonged droughts interfere with setting of nuts.

When it began to be realised by coconut planters that ordinarily fertilization was necessary to produce coconut fruits, it was customary to consider all the female flowers, even when they were not ripe to receive pollen, as fertilized or at least pollinated flowers. Thus in 1898 the late J. M. de Sa ⁽²⁰⁾, then a District Administrator of the Village Associations of Goa, wrote in his book "O Coqueiro" that he had seen pollinated or fertilized flowers even in unopened spathes: and the same idea was repeated about 14 years later by L. C. Brown ⁽⁵⁾, late Inspector of Coconut Estates in the F. M. S. in a communication made to Mr. H. H. Smith, the senior author of the *Consols of the East*. On this view Fredholm ⁽⁹⁾, who, as far as I am able to make out, was the first man to correct the view, remarked thus:—"But when you state that pollination takes place to a certain extent before the actual full opening of the sheath, so that young fruit, which may or may not properly set, is observed half-formed as soon as the flower-spike comes into view, then you are wrong. You have evidently mistaken the female flower bud for the young fruit (the fertilized ovum). In this plant in-breeding is so exceptionally well guarded against that it is well-nigh impossible, the pollen grains and the ovules of one and the same inflorescence never arriving at maturity simultaneously. On this point I write, in my articles, as follows:—In-breeding or close-breeding is guarded against as much as possible in nature. It is prevented, in the case of the coconut palm, by a difference in the time of expansion of the male and female flowers on the same spadix, and as a palm rarely has more than one inflorescence at a time with open flowers, the pollination of the female flowers is generally brought about by pollen from the staminate flowers of another palm. Thus cross-pollination is the rule. The pistillate flowers do not expand before the staminate of the same spadix have shed their pollen and fallen out. Until that time the gynaecium remains completely covered by the perianth leaves."

Observations made by various other investigators such as Petch ⁽¹⁸⁾ in Ceylon, Sampson ⁽²¹⁾ in India, and Jepson ⁽¹³⁾ in Fiji, confirmed those of Fredholm's. But though the conclusions

of Fredholm appear to hold good in most of the countries where coconuts are grown, they are not universally true. Not only is there the possibility of exceptions occurring in places where normally the female flowers open when all of male flowers have been shed ⁽¹⁰⁾, but in certain places as in the warm, humid lowlands of Malaya "the female phase not only begins, but most frequently ends before, or at the same time as, the male phase, thus rendering self-pollination the rule instead of being an occasional chance occurrence ⁽¹²⁾." Messrs. Jack and Sands from whom the above quotation is taken have succeeded in obtaining fruits by bagging an unopened coconut inflorescence, and my observations on the dwarf varieties in the Botanic Gardens, Singapore, lend support to their conclusions. This behaviour of the palms in the F. M. S. may be due to some hereditary qualities; but is also possible to attribute this variation in the anthesis of coconut flowers to climatic conditions and the fact that Van der Wolk ⁽²⁴⁾ has shown that the ripening of female flowers is hastened by covering them with black paper so as to reduce light and warmth, may be invoked in support of this

The mode in which the coconut flower presents its stigma for the reception of the pollen is quite different from that of most of our garden flowers. In the latter the petals become loose as the stigma matures, open out exposing the stigma and then after a time wither and drop off. Such however, is not the case with the members of the perianth of the coconut flower. They never drop off unless the ovary or the fruit itself is detached and when young they form a very tight case in which the pistil is protected. The perianth leaves grow extremely slowly attaining the final length of about two to three centimetres, whereas the pistil inside grows comparatively at an enormous rate so that it forces them apart and extrudes the stigma-bearing region, on the ripening of which the stigmatic grooves become exposed to receive pollen. There is a secretion of nectar both from these grooves as well as from the region surrounding them. The period during which the female flower remains receptive varies in different places. At Akyab ⁽¹⁰⁾ and at Peradeniya ⁽¹⁸⁾, for instance, it is about 24 hours, while in Los Banos ⁽¹⁾ and Singapore it is about 2 to 3 days.

Biology of Pollen.

Pollen grains of the coconut are spherical and smooth, without any asperities, but on exposure of a few seconds they turn ellipsoidal with a single meridian groove or suture which, according to Kerner ⁽¹⁴⁾, is characteristic of palms. On wetting the grains resume their original shape, the longitudinal fold disappearing. This groove seems to point out that coconut pollen belongs to the type adapted to be transported by insects rather than to the type easily wafted by winds. There are two kinds of pollen grains, fertile and infertile, the latter are about half the size of the former. Aldaba's ⁽¹⁾ countings show that infertile pollen grains vary in the

Philippines from 3 to 33 per cent, but in Singapore the abortive grains appear to be very few.

It is the general belief that pollen grains of palms, when kept in dry condition, retain their fertilizing properties unimpaired for a very long time so that they can be exported to distant countries for the purpose of pollinating certain varieties which are desired to be crossed, and Kerner (¹⁴) quotes a tradition which says that the pollen of Date-palms together with that of Hemp and Maize, can be used effectively for artificial pollination even after a lapse of eighteen years. Hence I made pollen culture in cane sugar solutions to ascertain whether there was any possibility of female flowers being fertilized in nature with the pollen from the same inflorescence. At the time I started my studies I had come across only a few exceptions at Akyab where female flowers ripened before the male flowers in the same inflorescence had finished shedding their pollen, but had not seen the paper by Aldaba on the subject, nor did I know of the studies made by Jack and Sands which show that in Malaya self-pollination is the rule rather than the exception. Hence I duplicated many of the results obtained by others. In these studies I obtained the best results with 20% cane-sugar solution, and it was found that every day more and more pollen grains lost their vitality when kept under ordinary conditions till on the seventh day only 3% showed any germination and after that period no grains were seen germinating. Aldaba's (¹) findings show that in Los Banos, 25 to 30% are the best cane-sugar solutions for effecting germination of pollen grains of the coconut, that pollen remains viable for two to nine days, and that pollen grains from different trees do not maintain their viability for the same length of time.

Now we have seen above that in many places the staminate flowers fall off before the stigmas of the female flowers in the same inflorescence become receptive and it is usual among the planters to argue that where this occurs in-breeding or fertilization by the pollen from the same inflorescence is impossible and that emasculation of the inflorescence of which female flowers only are to be used is unnecessary. That this way of arguing is fallacious is shown by the above results which show that pollen may, under ordinary conditions, retain its vitality even for nine days. Added to this there is the danger of female flowers ripening earlier than usual and, thereby, of their getting self-pollinated, thanks to the reduction of light and warmth caused by the bags used to protect the flowers from foreign pollen; for in the above referred experiments with black paper Van der Wolk (²⁴) was able to secure self-pollinated nuts from trees where under ordinary conditions self-pollination was impossible.

When, instead of being kept exposed to ordinary atmospheric conditions, the pollen grains were preserved in celluloid capsules such as are used in administering quinine powder to patients, and the capsules were coated with melted tallow, a greater percentage of pollen grains were found to remain viable. Sampson (²¹)

writes in his *Coconut Palm* that coconut pollen can be preserved for several days in hermetically sealed tubes without losing its vitality. But further investigations in this matter are needed so that a system of artificial pollination may be evolved which will insure the rapid improvement of so important a crop as the coconut. It should also be such as to render it easy for planters to know not only the maternity but also the paternity of the seeds chosen. "If pollen grains are wetted," writes Sampson ⁽²¹⁾, "they at once assume a rounded shape and commence to disintegrate within the space of two or three hours. It is thus evident that, in the moist tropical climate which favours the growth of the coconut palm, there is no chance of the shed pollen grains remaining dormant till the female flowers are open and receptive." We have seen that when exposed to ordinary conditions in a laboratory in Singapore pollen remained viable for even seven days. But to test how long the vitality of pollen may remain when it is exposed to an atmosphere saturated with moisture, some was dusted on to a slide kept on a cell and put into a closed petri dish partly filled with water. It was found that had after $6\frac{1}{2}$ hours exposure to such saturated atmosphere the pollen had not lost its vitality, but after 12 hours exposure to such conditions more than 75% of the grains had lost their vitality.

Pollinating Agents.

In most countries, as has been explained above, there is very little chance of the female flowers being fertilized by the pollen from the same inflorescence. This means, therefore, that they have to depend for pollen upon other inflorescences, either from the same tree or from others. The chances of obtaining pollen from an inflorescence on the same tree are very much reduced by the fact that it is only occasionally that a fresh inflorescence opens before the previous one has finished flowering, and this in spite of the vigour and prolificness of some trees. This means that a large number of female flowers have to depend for their pollen on other trees. This explains why in most countries there is so much variation in the seedlings raised from the nuts of the same tree or even from the same inflorescence, when seedlings raised from dwarf coconuts of Malaya where cross-pollination is an occasional chance occurrence behave so like their parent palms ⁽¹²⁾.

Since the stamens and pistils are borne in separate flowers, the pollination in nature can only take place with the pollen brought by winds, or by insects and other creatures that are attracted to them because of their peculiar scent, colour, nectar etc. Knuth ⁽¹⁵⁾ remarks that the coconut is pollinated through the agency of wind, but quotes Fr. Dahl who noticed the birds *Charmosyna subplacens* Sel., *Cinnyris frenata* S. Mull. and *C. corinna* Salvad. as the frequent visitors of coconut flowers in the Bismarck Archipelago. According to Petch ⁽¹⁸⁾, pollination is effected chiefly by bees and hornets in Ceylon, though from the structure of the flower, he admits that the wind may be also responsible for the transference to a great

extent. Hunger states that the coconut is pollinated by wind as well as by insects, and among these figure wasp (*wespen*), bee (*begin*), fly (*vliegen*), beetle (*kevers*), and ant (*mieren*). Aldaba ⁽¹⁾ working in the Philippines found so little pollen carried by wind from one tree to another that he attaches very little importance to cross-pollination by this agent. The principal insects observed by him as probable pollinating agents are the house fly (*Musca domestica* Linn.) several species of *Lucilia* (Diptera), *Vespa luctuosa* Sauss., *Sarcophaga* sp. *Rhynchium atrum* Sauss., *Apis indica*, *Trigona biroi* (Hymenoptera) and *Prionocerus caeruleipennis* Perty (Coleoptera). Sampson from the peculiar structure of the flower and the honey glands infers that nature has intended that the coconut flowers should be fertilised by the aid of insects. Burkill ⁽⁶⁾ has noted *Apis dorsata* and *A. indica* on coconuts in Singapore, but remarks that this genus is often found in the Malay Peninsula on palms overwhelmingly "on male flowers, or on flowers in their male stage, obtaining food without giving what would seem to be an adequate return" and that only *Apis indica* has been seen behaving in that manner in Singapore. The observations of Jack and Sands ⁽¹²⁾, on the pollination of coconuts in the Malay Peninsula are of unique interest. "In three unopened inflorescences which were bagged in muslin bags, self-pollination was effected naturally and fruits were formed, while in three other inflorescences which were emasculated immediately on opening, no pollination took place and no fruits were formed, though the female flowers behaved normally and although male flowers on adjacent trees were in full bloom. In a similar connection, it has been observed that odd isolated coconut trees growing even under bad conditions produce fruit so that self-pollination must take place. When coconut flowers are in full bloom, at about 10 a.m., when the dew has dried up and when the gentle breezes frequently begin, clouds of pollen can be seen floating away in sunlight. In a very slight breeze these pollen clouds do not travel far owing to the weight of the pollen but it is highly probable that with the strengthening of the breeze as the day advances the pollen clouds are carried to considerable distance and thus cross-pollination is effected." From this it would appear that insects play an unimportant part in the pollination or rather cross-pollination of coconut flowers in the Malay Peninsula. However, as said above, in most countries where coconuts are grown the coconut flowers behave differently. Aldaba's ⁽¹⁾ results support the view held by many planters outside the Peninsula that an isolated tree does not bear fruit if male flowers in the succeeding cluster do not shed pollen during the period when the stigmas of the female flowers below are yet in a receptive condition, and that a tree in a grove under the same conditions bears fruit. Jepson ⁽¹³⁾ who paid a special attention to the insects beneficial or otherwise to coconuts, after saying that pollination of coconuts in Fiji is dependent on wind and insects, among which he noticed bees and some black hymenoptera, attributes the dropping in many districts of Fiji of female flowers in large numbers, resulting in poor yield, to the

great scarcity of insect life in the vicinity of an open inflorescence. He corroborates his view by the observation that, on estates where bees are present in large numbers owing to artificial rearing or otherwise, the yield of nuts is very remarkable high. On these grounds he advises the planters in Fiji to introduce bees on their coconut estates with the view of increasing their crops.

My own studies on this subject have not been very extensive, but they throw some further light on the various points raised by the previous investigators. Regarding the ant as pollinator Petch (18) writes: "In considering the potential insect visitors to flowers in the Tropics one has always to take into consideration the ubiquitous ant. At first sight it seems possible that this insect may take part in the conveyance of pollen from male to the female flower, especially when the periods of the inflorescences overlap. In that case they might convey pollen from one inflorescence to another on the same tree. But it is improbable that they should convey pollen from one tree to another, because the journeys of this species, as a rule, do not extend to two trees.

"There is, however, a special provision on the female flower of the coconut which more or less effectually excludes ants from the work of pollination. The region below the stigma, almost the whole of the area which is exposed when the female flower opens, bears a large number of pores. When the flower is ripe these exude a quantity of moisture which, at least in fine weather, forms a ring of liquid round the stigma and prevents the ants reaching the latter. It is not uncommon to see a crowd of black ants congregated round the edge of this ring. It is probable that, as is usual in cases of this kind, the liquid contains some sugar, so that the ants obtain what they want without robbing the stigma. In any case, it keeps the ants away from the stigma. The position of these water pores can be clearly seen on the young fruit where they are indicated by small whitish spots. These spots owe their colour to masses of minute crystal which are deposited by the liquid."

In the Botanic Gardens, Singapore, I have not found the secretion is in sufficient quantities as to exclude the ant from the stigmas. Hunger has included ants among the pollinators of coconut flowers, and Aldaba admits the possibility of pollination by ants when he presumes the conveyance of pollen by ants as the probable reason for the development of a nut in an emasculated bagged inflorescence. However it may be that the climate of Peradeniya is favourable for the accumulation of the liquid in such large quantities. In places, therefore, like Singapore, where secretion is not in sufficient quantities as to exclude the ant from the work of pollination, it will play an important part particularly with coconuts where male and female flowers ripen together so as to insure self-pollination.

The insects that seem to do yeoman service in pollination or cross-pollination of coconuts in Singapore are some species of *Melipona* (the dammar bees), *Apis dorsata*, and some *Muscidae*

principally *Musca* very near *nebulo* (the common, Oriental house-fly), *Lucilia* sp., and *Pycnosoma* sp. These were seen visiting freely both the male and female flowers, though the flies seem to engage themselves more in sipping the honey from the female flowers than in feeding on the pollen or honey in the male flowers. *Apis indica* was a rare visitor to the male flowers, but this bee, according to Burkill, does not give an adequate return for the food it obtains from the flowers of palms. Wasps do not appear so useful as the bees in pollination as they visit the flowers mostly for the purpose of preying on the bees and other insects which are usually beneficial to the pollination of palms. *Vespa cincta* was frequently observed hunting insects and only on one occasion it was observed alighting on male flowers. *Cyrtostomus pectoralis* Hors., was seen but once sipping the honey from the female flowers of a coconut and according to Mr. Chasen of the Raffles Museum, Singapore, *Anthreptes malaccensis* is the sunbird which is almost invariably associated with coconuts in the Malay Peninsula. Various other birds were also seen in the vicinity of coconut inflorescences, but it must be borne in mind that even those birds which possess especial adaptations in their beak for extracting nectar from various kinds of flowers, often visit the flowers for the purpose of capturing insects for their prey and hence the utility of birds in places where there are insects such as bees to pollinate the flowers, is, like that of wasps, doubtful.

My emasculation experiments on dwarf varieties gave results which differ from those obtained by Jack and Sands in the F. M. S. in that I have been able to obtain nuts even though the nearest tree from which pollen could be brought was about 50 yards away from the tree, and though the inflorescences looked sickly and the nectar secretion was reduced because of the injury resulting from the emasculation. Further I have seen nuts developing on those few inflorescences where female flowers became receptive only after the falling of the male flowers. It makes me wonder therefore, whether the failure in F. M. S. to obtain fruit from emasculated inflorescences was not due to the injury resulting from the emasculation or to the absence or scarcity of insect life useful in the pollination of coconut flowers. By keeping unpollinated emasculated inflorescences side by side with the emasculated but artificially pollinated ones it would be possible to throw considerable light on this point.

Influence of Manures.

It is a known fact in horticulture that application of too much nitrogenous manures causes the plants to vegetate at the expense of flowers and fruits, while lime and phosphates tend to divert this energy in the opposite direction, namely to the production of flowers and fruits. Does the same thing occur in coconuts? What manures exert beneficial influence on the flower production in coconuts and what others act detrimentally? Unfortunately coconuts have received very little attention in this line from the in-

vestigators and hence our knowledge is at present very limited. We only know that tillage and manures increase the yield and that coconuts require more potash, and probably salt also, than many other fruit crops. However, it must be understood that to study the influence of manures on flower production is not an easy matter in the case of coconuts especially because the immediate effect of manures on estate is often to increase the vegetative growth and to reduce the yield of crops. In making such experiments due consideration has to be given to the fact that the yield in coconuts can be increased in a number of ways, the following being the principal ones:—

1. By the increase in the number of female flowers in each spadix;
2. By causing to grow the spadices that otherwise would have been dormant or abortive;
3. By the rapid production of leaves and inflorescences, due to increase in the number of leaves produced during a given time.
4. By increasing the ability of the ovary to be fertilized even under adverse conditions or increasing the vigour of pollen so that it may be effective in fertilizing the ovum.
5. By reducing the fall of immature nuts due to malnutrition of the plant.

All such points have to be considered in a study of the effect of manures before anything can be definitely said about their influence on the production of flowers. Copeland (⁷) has shown that in the Philippines the leaves take one and a half years from their first appearance until their full development, and that another one and half years are required for fruits to mature in their axils. This period, no doubt, will vary according to the local conditions; but, at any rate it gives us an idea how long the effects of a treatment will last considering that the present treatment will, to a great extent, determine the nature of the embryonic leaves and inflorescences and, therefore, the future crop. Let us assume by way of illustration, that we have started cultivating a very neglected coconut tree. The first effect of this treatment may be that the suppression of many inflorescences and a considerable improvement in the general aspect of the tree. The next symptom of this treatment may be the reduction in dropping of immature nuts, later on the annual number of leaves produced may increase and with them the number of inflorescences, then the number of abortive spadices may gradually be lessened and lastly it may occur that the inflorescences produced may be longer, bearing a greater number of female flowers. Many of these flowers may at first drop because the palms are too weak to produce a sufficient quantity of good pollen. The various changes may not take place in the order mentioned above; but the illustration will, I think, show the necessity of making very careful records for a number of years and herein lies the chief difficulty of experiments. Judging, however, from indirect evidence it can be said that good treatment does increase the

number of inflorescences on a tree and of female flowers in each inflorescences. Many of the villagers' holdings in Goa are situated at the foot of laterite hills, far away from any human habitations and they do not usually receive any attention from their owners. The coconuts trees in such holdings have, as a rule, many spadices aborted, those that are produced have a stunted growth, each bearing ordinarily not more than four or six female flowers: while on holdings which are under a more careful cultivator or near a well or cattle byre the trees produce more spathes and more female flowers in each spadix. Sampson (²¹) is also of opinion that manuring does induce to an appreciable extent, the rapid development of new bunches of flowers, drawing a basis for his assertion from the better behaviour of coconut trees near a dwelling than that of those growing at a distance from where plant food is plentiful in the soil.

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BRANCHED COCONUT PALMS AND THEIR FERTILITY.

Apropos of the note on the *Fertility of Branched Coconut Palms* by Mr. Burkill, published on page 1-2 of Vol. III of this *Bulletin*, the following may not be without interest to readers.

Normally one coconut fruit gives rise to one shoot and this in its turn to one stem. It is not infrequently, however, that one meets with wide deviations from this normal phenomenon. A nut, for instance, may on germination, give rise to more than one shoot, each arising from a separate carpel in the nut. The writer has not come across an instance where a nut had more than two fertile carpels; but it must be remembered that the coconut has a trilobular ovary wherein normally two of the locules become abortive. Cases, therefore, may occur where all three carpels may be stimulated to become fertile as in some species related to *Cocos nucifera*. Forbes reports of "a nut with three cells separated by leathery walls." Sampson (¹⁶) appears to have seen cases where the septa separating the ovules were hard and not leathery. Forbes, in his article above referred to writes: "I have seen also nuts with cells ranging from four to eight and ten. I send you a rough outline sketch of a tree which has come up from a nut of fourteen cells, all of which germinating, producing a tree with fourteen stems